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M E M O R A N D U M

July 21, 1986

TO: Martin Harper, Harper-Owes

THROUGH: Lynn Singleton LS

FROM: Will Kendra WK

SUBJECT: Shoreline Survey and Source Inventory of Wapato Basin, Lake Chelan

ABSTRACT

A shoreline survey of Wapato Basin, Lake Chelan, was conducted April 15-16, 1986. Of 20 sources sampled, 12 were thought to include irrigation return flows, three were likely urban runoff, and two were streams draining relatively undeveloped watersheds. The remaining three sources were of unknown origin, but cluster analysis suggested they were a combination of natural and irrigation return flows. Nitrate/nitrite concentrations were highest in Chelan Reclamation District agricultural drains, while ammonia and fecal coliform concentrations were highest in urban runoff. Total phosphorus concentrations were greatest in streams draining relatively undeveloped watersheds. Total daily nutrient loads to Wapato Basin were approximately 100 lbs. nitrate/nitrite, 1 lb. ammonia, and 20 lbs. total phosphorus.

INTRODUCTION

Lake Chelan is the largest natural lake in Washington. The lake consists of two basins separated by a shallow constriction known as the "Narrows." Lucerne, the uppermost basin, is 38 miles long and largely undeveloped. Wapato Basin (Figure 1) is only 12 miles long but its shores and uplands are considerably developed. The cities of Chelan and Manson border Wapato Basin, as do a number of nearshore homes. Fruit orchards are the prominent feature of Wapato Basin uplands. A detailed description of the lake and associated land use patterns can be found in EPA (1984) and Chamberlain et al. (1985).

Lake Chelan serves a variety of beneficial uses including domestic and agricultural water supply, recreation, and hydropower production. Increasing residential, agricultural, and recreational development in the

drainage may threaten the existing high quality of Lake Chelan waters. Sources of contamination in Wapato Basin include urban runoff, irrigation return flows, septic tank leachate, sewage lift station overflows, and recreational activities.

The Water Quality Investigations Section (WQIS) of Ecology conducted a shoreline survey of Wapato Basin to identify and characterize influent sources of fecal coliform bacteria and nutrient enrichment. Survey data will be used to help design the upcoming Lake Chelan Water Quality Assessment.

METHODS

Sampling of streams and drains tributary to Wapato Basin was performed April 15-16, 1986. Overcast skies produced intermittent rainfall on April 15, but weather on April 16 was clear. Field assistance was provided by Lynn Singleton of WQIS.

Lake Chelan typically loses elevation to hydropower production until April and is subsequently filled by spring runoff through June. The Public Utility District (PUD) of Chelan County is licensed to fluctuate pool elevations between 1,079 and 1,100 ft. The present survey was conducted at a lowered pool height to allow detection and sampling of discharges located below the high water mark (e.g. ground water inflows and subsurface pipes). Lake elevations on April 15 and 16 were 1,089.7 and 1,089.8 ft., respectively (B. Dearing, Chelan PUD, personal communication).

Areas suspected of having an influent source were identified through a review of available maps, photos, and literature. These were: 1) areas below drainage swales; 2) sites of intermittent and perennial streams; 3) locations where submerged aquatic vegetation fanned out from a point; and 4) agricultural and storm drain outfalls. Influent sources were located in the field by visual inspection of the shoreline from a boat. Particular attention was focused on areas with excessive plant growth and on areas downslope from suspected septic system failures (EPA, 1984).

Twenty influent sources were sampled during the survey (Figure 1). An additional mid-lake site was sampled for comparison. Survey work extended uplake to Missouri Harbor, located just north of the Narrows. Two sampling sites were actually located within Lucerne Basin, but their proximity to the Narrows and similarity of land use merit their consideration as sources influent to Wapato Basin.

Parameters measured were discharge, specific conductance, nitrate/nitrite (combined form), ammonia, total phosphorus, and fecal coliforms. Flows were estimated by: 1) the area-velocity technique (Marsh-McBirney current meter); 2) use of a "bucket and stopwatch"; or 3) visual comparison to other discharges. Specific conductance was measured in the field with a Beckman Solu-Bridge conductivity meter. Nutrient samples were acidified, iced, kept in the dark, and transported to Ecology's

Manchester laboratory on April 17. Fecal coliform samples were iced, kept in the dark, and shipped to a laboratory within 30 hours. Bacteria samples collected on April 15 were analyzed at the Chelan/Douglas Health District laboratory in Wenatchee (MPN technique), while samples collected on April 16 were analyzed at Ecology's Manchester laboratory (MF technique). Analytical procedures at both laboratories conformed to EPA (1979) and APHA et al. (1985).

RESULTS AND DISCUSSION

Table 1 provides a detailed description of inflows that were sampled during the survey. Where possible, the source of each inflow was noted. A number of upland orchards apparently use French drains to collect excess irrigation water for ultimate return to the lake. As a result, 15 of the 20 influent sources sampled were thought to contain, in part, irrigation return flows. Of the five remaining inflows, three were likely urban stormwater runoff outfalls and two were streams believed to drain relatively undeveloped watersheds.

Due to their proximity, inflows 6 and 7 were originally suspected of sharing the same source. However, differences in water quality negated this hypothesis. The aqueduct shown in Figure 1 was formerly an intake, but is now believed to route Joe Creek/Wapato Lake waters to Lake Chelan in the vicinity of Greens Landing (M. Jeffries, Lake Chelan Reclamation District, personal communication). Stink Creek is partially diverted for hydropower production a short distance upstream from the lake, but it is also thought to drain into Lake Chelan near Greens Landing (D. Clausing, Ecology Central Regional Office, personal communication). Further investigation is required to determine if inflows 6 and 7 do, in fact, originate from these sources.

Several general field observations were noteworthy. First, a number of nearshore homes rely on raw lake water for potable water supply. Intake lines extending out from shore were abundant, particularly along the south and west shores. Also, the burning of lawn trimmings and other debris on exposed beaches appears to be a common practice among shorefront residents. Finally, only some of the storm runoff outfalls noted in Chamberlain et al. (1985) were evident; the remainder may have been submerged. Additional field observations are outlined in the Appendix.

Table 2 shows water quality at the 21 sampling sites. First Creek (site 4) had the largest discharge. Specific conductance was elevated at all sources that were believed to include irrigation runoff (the irrigation season typically begins around April 1 [CDHD, 1981]). Nitrate/nitrite concentrations were highest in Chelan Reclamation District agricultural drain #7 (site 9), while ammonia concentrations were greatest in stormwater runoff from the city of Manson (site 11). Fecal coliform densities were highest in stormwater runoff from the city of Chelan (site 20). The creek draining Purtteman Gulch (site 18)

contributed the largest nitrate/nitrite load to Wapato Basin, while First Creek provided the greatest total phosphorus load. An unknown source (site 17) contributed the highest fecal coliform load.

Source data collected during the present survey generally paralleled historical water quality data for the months of March and April (Table 3). An exception was nitrate/nitrite concentrations, which were approximately twice as high in 1986. Also, Beck and Associates (1982) sampled storm drains discharging to the lake in March 1982 and found nitrate/nitrite levels of 0.15-0.25 mg/L and total phosphorus levels of 0.28-0.32 mg/L. In 1986, nitrate/nitrite concentrations in urban runoff were two to three times higher.

Influent source data for 1986 were grouped according to known or suspected origin (Table 4). Nitrate/nitrite concentrations were highest in Chelan Reclamation District agricultural drains, but loads were greatest in natural streams which were supplemented by irrigation return flows. Ammonia concentrations were highest in urban runoff, but ammonia loads from all sources were low. Total phosphorus concentrations and loads were greatest in streams draining relatively undeveloped watersheds. Fecal coliform densities were highest in urban runoff, but the category of "unknown" sources accounted for the largest bacterial load. Total daily nutrient loads to Wapato Basin were approximately 100 lbs. nitrate/nitrite, 1 lb. ammonia, and 20 lbs. total phosphorus.

Cluster analysis (Romesburg, 1984) was applied to the flow-weighted conductivity and concentration data in Table 4 in an attempt to identify the origin of unknown sources 15, 16, and 17. The "tree" depicted in Figure 2 shows the hierarchy of similarities among all the pairs of sources. To determine the degree of similarity between two sources, trace a path from the first source upward through the tree and downward again to the second source. The highest point on the path connecting each pair of sources is a measure of the similarity of the two. For example, the similarity between sources 15 and 16 is 1.1 while the similarity between source 15 and urban runoff is 4.4. The smaller the value, the more similar two sources are. Thus source 15 is more similar to source 16 than it is to urban runoff.

Romesburg (1984) defines a cluster as a set of one or more objects (sources) that we are willing to call similar to each other. A cluster can be a single source, if we are willing to call no other sources similar to that source. Alternatively, a cluster can be as many as all of the sources, if we are willing to call all of them similar to one another. Romesburg notes that it may seem odd to use the word "willing", but it is an appropriate term here. To call two or more sources similar, we must be willing to neglect some of the differences that make them nonidentical.

The dashed reference line in Figure 2 intersects four clusters of sources (the line was drawn to guide this discussion--it has no other significance). The first cluster (shaded for clarity) consists of the

following sources: 1) natural streams, supplemented by irrigation returns; 2) ground water, possible fed by irrigation returns; and 3) unknown sources 15, 16, and 17. The remaining three clusters are: 1) Reclamation District agricultural drains; 2) natural streams draining relatively undeveloped watersheds; and 3) urban runoff. Sources in the first cluster are more similar to one another than they are to the other three clusters. Hence cluster analysis suggests that the origin of the unknown inflows may be a combination of natural sources (surface and ground water) and irrigation return drainage.

RECOMMENDATIONS

The contractor for the Lake Chelan Water Quality Assessment could suitably characterize the sources tributary to Wapato Basin through monitoring of several representative sampling sites. To this end, the following inflows are recommended for periodic sampling:

Type of Source	Recommended Sampling Site
Urban runoff	11 (Manson) and/or 20 (Chelan)
Chelan Reclamation District agricultural drains	8
Natural streams draining relatively undeveloped watersheds	4
Natural streams, supplemented by irrigation returns	3 and/or 18
Ground water, possibly fed by irrigation return flows	12

Because the present survey was conducted at a lowered pool elevation, the contractor is advised to field-verify the feasibility of sampling these sites at full pool. Sites with underwater outfalls may be sampled upstream of the lake through manholes or other means of access. Further investigation of inflows 6, 7, 15, 16, and 17 is recommended to elucidate their origin.

cc: John Hodgson
Ann Jenson

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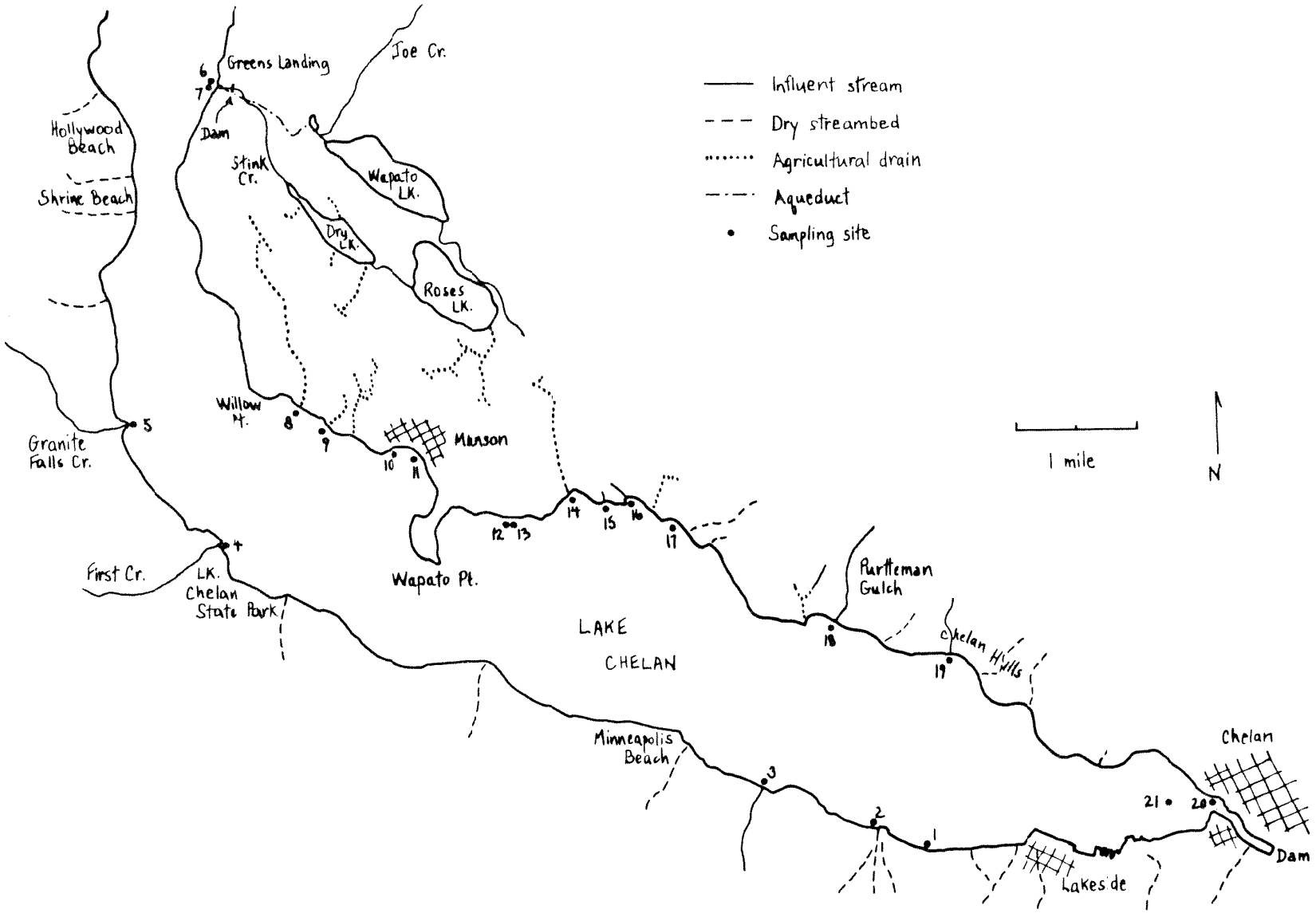

Figure 1. Map of Wapato Basin, Lake Chelan, showing location of influent waters sampled during a shoreline survey conducted April 15-16, 1986 [adapted from USGS (1968), USBR (1974), EPA (1984), and Chamberlain, et al. (1985)]. Stream lengths shown are not necessarily in their entirety.

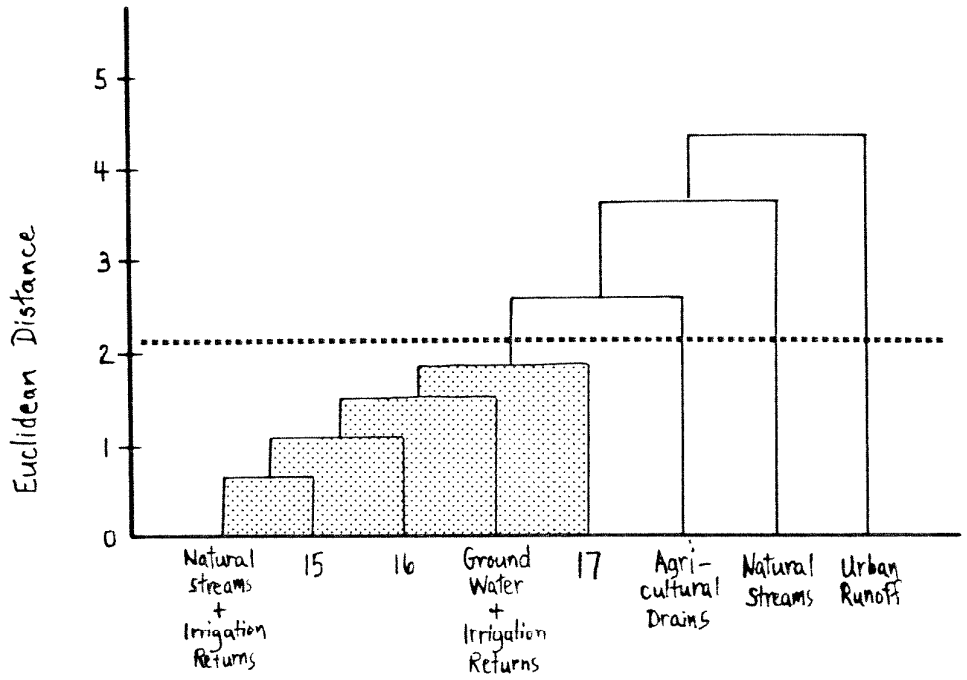

Figure 2. Tree derived from cluster analysis of grouped source data (Table 4). The cophenetic correlation coefficient for this analysis was 0.95, which indicates that the tree accurately represents the similarity between sources.

Table 1. Description of sites sampled during a shoreline survey of Wapato Basin, Lake Chelan, on April 15-16, 1986.

Site Number	Location	Description	Source
1	S. shore, W. of Lakeside; 3rd house W. of USGS gage and "Tsillan" road sign (approx. 0.5 mi. W. of gage)	4" concrete drain tile in bulkhead; algae evident; resident claims drain runs often; located below high water mark; EPA (1984) photos suggest submerged vegetation fans out from this vicinity	Suspect ground water draining upland orchards
2	S. shore between Lakeside and Minneapolis Beach, approx. 1 mi. N.W. of USGS gage; gray shoreside residence	4" PVC line in bulkhead; algae evident; surface runoff on beach from pipe and possibly ground water seepage; pipe located below high water mark	Unknown, possibly ground water drainage from upland orchards
3	S. shore, approx. 1 mi. S.E. of Minneapolis Beach, where US Rt. 97 begins its uphill ascent	Creek draining onto beach; algae evident; fair amount of fine and course sediments deposited on beach; Equisetum borders channel upstream of beach; EPA (1984) photos suggest submerged vegetation fans out from mouth	Resident claims it's a perennial, spring-fed creek supplemented by irrigation return flows from upland orchards
4	S.W. shore at Lake Chelan State Park	First Creek	18.2 sq. mile watershed
5	W. shore, approx. 1.2 mi. N.W. of Lake Chelan State Park; at apex of small point located across lake from Willow Point	Granite Falls Creek; flows out of 18" concrete pipe in bulkhead; algae evident; pipe likely just below surface when lake full	Natural; estimate 40% of creek flow diverted to hydropower generator (?) located at southernmost residence on point (note: at present there is no existing state-issued water right for hydropower production on this creek)
6	E. shore at Greens Landing	May be Stink Creek or Joe Creek/Wapato Lake outlet; 2 metal pipes (24") emerge from shore at or slightly below high water mark, approx. 100' apart; site 6 is northernmost pipe; algae abundant at both outfalls, more so at site 6; nearshore lake surface w/ foam; unpleasant odor; dam on creek approx. 0.1-0.2 mi. upstream	Likely Stink Cr. drainage or Joe Cr./Wapato Lk. drainage; possibly combination of both, supplemented by irrigation return flows from upland orchards

Table 1. Continued.

Site Number	Location	Description	Source
7	E. shore at Greens Landing	Same as site 6 (site 7 is southernmost pipe)	Same as site 6
8	N. shore, approx. 0.4 mi. S.E. of Willow Point	Creek/drainage ditch runs down hillside, enters dense shrub vegetation, emerges onto rocky shore at several points (diffuse flow); algae and cress-like vascular plants abundant on beach	Irrigation return flows from upland orchards (Lake Chelan Reclamation District agricultural drain #6)
9	N. shore, approx. 0.7 mi. S.E. of Willow Point, at site of shoreside residence located adjacent to orchards	Creek passes through residential lawn, emerging as a series of cascades on steep, rocky shore; algae evident	Irrigation return flows from upland orchards (Lake Chelan Reclamation District agricultural drain #7)
10	N. shore, approx. 0.2 mi. W. of Manson Bay Park	Apparent storm sewer outfall (12" corrugated pipe) located below high water mark of lake; sampled within 45 minutes of brief but intense rain event	Likely urban runoff from city of Manson
11	N. shore, approx. 200' S.E. of Manson Bay Park	Apparent storm drain outfall concealed in shoreside brush at or near high water mark; litter in vicinity probably from this drain; nearshore lake water turbid - storm drainage has eroded 6" of sandy beach to expose a clay lens - continued erosion of this lens is probable source of turbidity; sampled 1 hr. after brief but intense rain event	Likely urban runoff from city of Manson
12	N. shore, approx. 0.5 mi. E. of Wapato Point isthmus; blue-green residence	6" metal pipe located 5' below edge of lawn; algae evident on beach; resident claims flow is perennial, but reduced to a trickle in dry years	Resident claims it's an outfall for a ground water collection system necessitated by the presence of a clay soil lens which limits infiltration
13	N. shore, approx. 0.5 mi. E. of Wapato Point isthmus; 2nd house E. of blue-green residence	6" metal pipe in bulkhead; water pools on beach; adjacent shore sediments spongy	Resident believes it drains area behind shorefront homes; possibly same source as site 12

Table 1. Continued.

Site Number	Location	Description	Source
14	N. shore, approx. 0.3 mi. N.W. of Old Mill Park; small shorefront park located 100' N.E. of site	Rectangular (4" X 16") drain opening onto beach slightly below high water mark; algae evident; beach erosion from drain effluent has exposed a length of 6" PVC pipe which begins 20' from outfall and apparently extends beneath sediment surface out into lake; trace of H_2S in air	Likely adjacent wetland drainage and irrigation return flows (Lake Chelan Reclamation District agricultural drain #9)
15	N. shore at Old Mill Park, immediately N.E. of boat ramp near public docking facility	Creek draining onto beach of fine, woody debris; cress-like vascular plants abundant in and near creek; fish fry present in lake shallows at creek mouth	Unknown; emerges from 18" metal culvert in rip-rap a short distance upstream
16	N. shore, cove N. of point located approx. 0.2 mi. E. of Old Mill Park	Creek emerges from marshy grasslands as main channel (w/ waterfall) and several side channels; woody debris (esp. chips) covers beach throughout cove (thickness approx. 1'); H_2S present; creek has cut meandering channel through debris; large areas of debris saturated with water; cress-like vascular plants and fish fry present	Unknown, possibly irrigation return flows
17	N. shore, approx. 0.6 mi. S.E. of Old Mill Park; 100' N.W. of gray residence with outdoor tennis (?) court	24" pipe in bulkhead, slightly below high water mark; beach eroded from runoff; cress-like vascular plants and algae present	Unknown, possibly irrigation return flows
18	N. shore at Purtteman Gulch	Creek emerging onto beach from 2 culverts (48") which pass it under WA Rt. 150; beach eroded by creek; algae limited; cress-like vascular plants present; EPA (1984) photos suggest submerged vegetation fans out from mouth	Purtteman Gulch watershed (likely includes irrigation return flows)

Table 1. Continued.

Site Number	Location	Description	Source
19	N. shore, approx. 1 mi. S.E. of Purtteman Gulch	18" concrete culvert; flow quickly infiltrates beach; algae present near culvert and in lake shallows; EPA (1984) photos suggest submerged vegetation fans out from this vicinity	Unknown, possibly ground or surface water drainage from Chelan Hills development
20	N. shore, approx. 0.1 mi. N.W. of US Rt. 97 Bridge, 5' W. of wooden bulkhead located near small brick building adjacent to Campbell's Lodge	16" steel storm sewer outfall	Likely urban runoff from city of Chelan
21	Mid-lake, approx. 0.5 mi. W. of US Rt. 97 bridge (at "no wake" buoy)	Control site; sample taken at surface (lake depth = 15')	Lake Chelan drainage

Table 2. Water quality at 21 sites sampled during a shoreline survey of Wapato Basin, Lake Chelan, on April 15-16, 1986.

						Nutrients				Approximate Load[e]			
Date	Site Number	Suspected[a] Source	Time	Discharge[b] (cfs)	Cond.[c] (µmhos/cm)	NO_3-N + NO_2-N(mg/L)	NH_3-N (mg/L)	Total P (mg/L)	Fecal[d] Coliforms (No./100mL)	NO_3-N + NO_2-N (lbs/day)	NH_3-N (lbs/day)	Total P (lbs/day)	Fecal Coliforms (No./sec.)
4/15	1	G	0930	0.0016	600	8.6	0.01	0.16	<3	<0.1	<0.1	<0.1	<1
	2	G	1000	0.0012	900	5.1	0.01	0.25	<3	<0.1	<0.1	<0.1	<1
	3	N	1040	(0.03)	550	5.2	0.02	0.39	43	0.8	<0.1	<0.1	370
	4	S	1150	5.63	100	0.04	0.01	0.35	<3	1.2	0.3	10.6	2,400
	5	S	1240	0.31	100	0.01	<0.01	0.05	<3	<0.1	<0.1	<0.1	130
	6	N	1450	(1-2)	400	0.01	0.02	0.09	43	<0.1	0.2	0.7	18,000
	7	N	1450	(1-2)	600	0.29	0.02	0.07	23	2.3	0.2	0.6	9,800
	8	A	1540	(0.3)	400	9.5	0.01	0.24	<3	15.4	<0.1	0.4	130
	9	A	1600	0.0848	550	14	0.02	0.32	<3	6.4	<0.1	0.1	40
	10	U	1625	0.0035	50	0.65	0.36	0.19	9	<0.1	<0.1	<0.1	10
	11	U	1640	0.0272	100	0.89	1.1	0.22	150	0.1	0.2	<0.1	1,200
4/16	12	G	0845	0.0173	900	4.0	0.01	0.10	7	0.4	<0.1	<0.1	30
	13	G	0900	0.0018	>1,000	1.5	0.01	0.07	<1	<0.1	<0.1	<0.1	<1
	14	A	0940	(0.2)	750	0.35	<0.01	0.12	<1	0.4	<0.1	0.1	30
	15	?	1000	(0.2)	550	1.2	<0.01	0.13	<1	1.3	<0.1	0.1	30
	16	?	1015	0.66	600	3.0	0.01	0.10	<1	10.7	<0.1	0.4	90
	17	?	1100	2.04	550	2.1	0.01	0.16	140	23.1	0.1	1.8	81,000
	18	N	1205	(2.0)	550	3.4	0.01	0.29	11	36.7	0.1	3.1	6,300
	19	G	1230	0.0044	600	1.7	0.03	0.28	<1	<0.1	<0.1	<0.1	<1
	20	U	1320	0.0025	50	0.68	0.14	0.16	1100	<0.1	<0.1	<0.1	780
	21	-	1345	-	50	0.04	0.01	0.01	11	-	-	-	-
Transport blank		-	-	-	-	0.02	0.01	<0.01	-	-	-	-	-

[a] A = Chelan Reclamation District agricultural drains; G = Ground water, possibly fed by irrigation return flows; N = Natural streams, supplemented by irrigation returns; S = Natural streams draining relatively undeveloped watersheds; U = Urban runoff; ? = Unknown source, possibly irrigation-related.

[b] Reported values less than 0.5 cfs were measured using bucket and stopwatch, while those greater than 0.5 cfs were gaged with a current meter. Exception: all values reported in parentheses were estimated by eye only - no actual measurements were made.

[c] Values reported to nearest 50.

[d] Samples collected 4/15 were analyzed using the MPN procedure; samples collected 4/16 were analyzed using the MF technique.

[e] Loads are only approximations because: 1. flows were sometimes estimated by eye, and 2. concentrations reported as less-than-detection-limit (<) were assumed to be equal to ½ the limit for computational purposes.

Table 3. Historical water quality data collected in March and April at six sites in or near Wapato Basin, Lake Chelan (source: EPA STORET retrieval).

Historical sampling site	Site number[a] (present survey)	Date	Discharge (cfs)	Cond. (μmhos/cm)	NO_3-N+ NO_2-N (mg/L)	NH_3-N (mg/L)	Total P (mg/L)	Fecal coliforms (No./ 100 mL)
First Creek	4	3/73-74[b]	-	101	0.02	-	0.02	<1
Stink Creek	6 or 7	3/23/76	2	540	0.12	0	0.02	-
Agricultural drain #6	8	3/23/76	0.2	475	4.35	0	0.24	-
Agricultural drain #7	9	4/27/76	0.2	421	3.30	0.06	0.32	-
Agricultural drain #9	14	3/23/76	0.2	910	0.18	0	0.09	-
Lake Chelan near dam	21	4/76-85[c]	-	56	0.05	0.03	0.02	1

[a] Historical station locations were generally the same as those sampled in the present survey.

[b] Average of 3/20/73 and 3/25/74.

[c] Average of April values, 1976 through 1985 (excepting 1977).

Table 4. Water quality characteristics of several types of sources influent to Wapato Basin, Lake Chelan, April 15-16, 1986. Means and totals were derived from Table 2, hence the same footnoted aids to data interpretation apply.

Source	Sites	Total Discharge (cfs)	Flow-weighted Cond. (μmhos/cm)	Flow-weighted Concentration				Approximate Load			
				NO_3-N + NO_2-N (mg/L)	NH_3-N (mg/L)	Total P (mg/L)	Fecal Coliforms (No./100mL)	NO_3-N + NO_2-N (lbs/day)	NH_3-N (lbs/day)	Total P (lbs/day)	Fecal Coliforms (No./sec.)
Urban Runoff	10,11,20	0.0332	100	0.85	0.95	0.21	207	0.2	0.2	<0.1	2,000
Chelan Reclamation District agricultural drains	8,9,14	0.5848	550	7.0	<0.01	0.21	1	22.1	<0.1	0.7	200
Natural streams draining relatively undeveloped watersheds	4,5	5.94	100	0.04	<0.01	0.33	<3	1.3	0.3	10.6	2,500
Natural streams, supplemented by irrigation returns	3,6,7,18	5.03	500	1.5	0.02	0.17	24	39.9	0.5	4.5	34,000
Ground water, possibly fed by irrigation return flows	1,2,12, 13,19	0.0263	850	3.8	0.01	0.14	5	0.5	<0.1	<0.1	30
Unknown, possibly irrigation-related	15,16,17	2.9	550	2.2	<0.01	0.14	99	35.1	0.1	2.3	81,000

Appendix. Miscellaneous field notes from shoreline survey of Wapato Basin, Lake Chelan, conducted on April 15-16, 1986.

Location	Observation
S. shore, E. of Lakeside; E. side of spit located approx. 0.2 mi. E. of ferry landing	Did not see "leaking pipes" reported in EPA (1984)
S. shore, W. of Lakeside; near USGS gage and "Tsillan" road sign	Washed-out wooden bulkhead 15-20' E. of sign may be the result of upland runoff; ground water seepage area on beach 50' W. of sign
S. shore between Lakeside and Minneapolis Beach, on point located approx. 1 mi. N.W. of USGS gage	Did not see 2 "pipelines with plumes" reported in EPA (1984), but did note abundance of submerged aquatic vegetation in vicinity
S.W. shore, approx. 0.4 mi. N.W. of mouth of First Creek (Lake Chelan State Park); at "Fenney" residence and house next door (to S.E.)	Subsurface periphyton on rocks below bulkhead
N. shore, approx. 1.0 mi. S.E. of Willow Point and 0.5 mi. N.W. of Manson Bay Park; at outfall of Lake Chelan Reclamation District agricultural drain #8	Ground water seepage evident in several places; algae and cress-like vascular plants present
N. shore near Manson Bay Park	2 storm drain outfalls, 1 uplake of park, the other just downlake; both at or slightly below high water mark
N. shore at base of Wapato Point, both E. and W. shorelines	3-4 storm drain outfalls on W. shore (1 flowing), 2 more on E. shore; all apparently drain adjacent residential development; several have caused beach erosion
N. shore, approx. 0.2 mi. S.E. Wapato Point isthmus (on point)	Pipe/pump apparatus at level of full pool discharging water under high pressure onto lake surface; conductivity = 50 (same as lake)
N. shore, approx. 0.6 mi. E. of Wapato Point isthmus; about 6 houses E. of blue-green residence (site 12)	12" pipe emerging from bulkhead; flow = 0.007 cfs (bucket/stopwatch method), conductivity = 850; source may be same as that of sites 12 and 13

Appendix. Continued.

Location	Observation
N. shore, approx. 0.6 mi. E. of Wapato Point isthmus; several houses E. of above site; rock residence between pre-fab. tan-and-green home and white home with satellite dish	4" white PVC pipe underwater may be an outfall rather than an intake
N. shore immediately W. of Old Mill Park	Large water intake facility
N. shore, point located approx. 0.2 mi. E. of Old Mill Park	Chelan/Douglas Health Dept. complaint of 2/27/86 to Ecology identified this site as having "very foul smelling" ground water seepage; did not see or smell evidence of this, but seepage/H_2S was evident in cove due N. (site 16)
N. shore, approx. 0.4 mi. S.E. of Old Mill Park (mid-way between sites 16 and 17)	Did not see reported outfall of Lake Chelan Reclamation District agricultural drain #10
N. shore, approx. 0.8 mi. S.E. of Old Mill Park; just uplake from residence with cedar-shake siding	6" downturned (via 90° elbow) PVC pipe; estimated flow = 0.15 cfs (eye), conductivity = 450; located at or near first dry streambed S.E. of site 17
N. shore, approx. 1.0 mi. S.E. of Old Mill Park; at site of second dry streambed S.E. of site 17	Moisture evident; ground water seepage?
N. shore, approx. 0.25 mi. W. of Purtteman Gulch; at outfall of Lake Chelan Reclamation District agricultural drain #13	Culvert located at or near high water mark; estimated flow = 0.2-0.3 cfs (eye), conductivity = 650
Narrow constriction (neck) approaching outlet of Lake Chelan	Several storm drain outfalls present on N. and S. shores